NATIONAL ADVISORY COMMITTEE FOR AERONAUTICS

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for

Army Air Corps

FLIGHT MEASUREMENTS OF STICK VIBRATION OF THE YG-1B AUTOGIRO EQUIPPED WITH TAPERED ROTOR BLADES

By F. J. BAILEY, JR. and F. B. GUSTAFSON

~~CLASSIFIED DOCUMENT~~

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SUMMARY

Records were made in flight of the periodic variation in the load in the control system of a YG-1B autogiro fitted with a new set of tapered rotor blades designed to eliminate periodic blade twist. Comparison with similar records obtained previously in tests of the original blades shows that the new blades considerably reduce the vibration of the control stick.

INTRODUCTION

It has been shown in reference 1 that, at the higher tip speed ratios, the loads in the control system of the YG-1B autogiro are subject to a periodic variation of considerable amplitude, at a frequency of three times the rotor speed. The source of the vibration is believed

to be in the periodically varying chordwise and radial displacement of the blade center of pressure from the blade center of percussion. Recently the Kellett Autogiro Corporation has developed, for use on the YG-1B machine, a new set of tapered rotor blades designed to eliminate as far as possible both the mean and the periodic parts of the chordwise displacement of the blade center of pressure. In the course of flight tests of the new blades, made by the N. A. C. A. at Langley Field, Virginia during November and December of 1939, the periodic variation in stick force was recorded in a manner similar to that employed during the tests of the original blades reported in reference 1. The results of the stick vibration measurements on the tapered blades are reported herein.

APPARATUS AND TESTS

Except for the change in blades the autogiro tested was a standard YG-1B machine similar to that used, with the original blades, in the tests reported in reference 1. The blades, which were tapered in plan form and thickness, had sections of a modified N. A. C. A. 23000 series.

In general the method of recording the variation in stick force was identical to that described in reference 1. Several minor differences may be noted, however. The natural frequency of the control force

recorder was reduced from 31 to 24.8 longitudinally and from 31 to 26.4 laterally; the use of lead shot at the hand grip to increase the inertia of the stick was discontinued, and the contacting device on the rotor hub was redesigned so that the azimuth position of the rotor could be established on the control force record at six points during each revolution. To free the control force record from possible high frequency vibrations due to the engine all records were made during steady glides with the engine stopped. The changes mentioned are believed to be incapable of appreciably affecting the results of the tests.

Five records were taken at indicated air speeds ranging from 30 to 110 miles per hour. Rotor speed, air speed, pressure altitude, and temperature were noted by the pilot. The pilot's observations of rotor speed and air speed were supplemented by recording instruments.

RESULTS AND DISCUSSION

Analysis of the records was carried out in the manner described in reference 1. It was found that the periodic part ΔM of the moment about either the lateral or longitudinal control trunnions could be closely approximated by a Fourier series having the form

$$\Delta M = A_3 \cos 3\psi + B_3 \sin 3\psi$$

where the angle ψ denotes the azimuth position of the rotor. The experimental values of the coefficients A_3 and B_3 for both the lateral and longitudinal moments are given in table I and are plotted against tip speed ratio in figure 1. The moment ΔM is considered positive when the air forces tend to tilt the rotor to the right and to the rear.

Comparison of the coefficients obtained in the tests of the tapered blades with the corresponding coefficients, taken from reference 1, for the original blades, indicates that eliminating the chordwise displacement of the blade center of pressure has considerably reduced the stick vibration. A better idea as to the magnitude of the reduction in stick vibration can be obtained from figure 2, where the amplitude $\left(A_3^2 + B_3^2\right)^{\frac{1}{2}}$ of the variations in lateral and longitudinal trunnion moments is plotted as functions of the tip speed ratio, for both the old and the new blades.

Langley Memorial Aeronautical Laboratory,
National Advisory Committee for Aeronautics,
Langley Field, Va., February 28, 1940.

Frederick J. Bailey, Jr.,
Assistant Aeronautical Engineer.

F. B. Gustafson

Frederic B. Gustafson,
Junior Aeronautical Engineer.

Approved by: Elton W. Miller,
Principal Mechanical Engineer.

DDH

REFERENCES

1. Bailey, F. J.: Flight Measurements of Stick Vibration of the YG-1B Autogiro. Conf. Memo. Report for Army Air Corps, N. A. C. A., Nov. 27, 1939.

TABLE I

Tip speed ratio	Rotor speed, rpm	Indicated air speed, mph	Pressure altitude, ft	Air temp., °F	Coefficients of trunnion moment, ft lb			
					Longitudinal		Lateral	
					A_s	B_s	A_s	B_s
0.107	203	29.0	5,000	31	-2.8	1.9	-2.8	1.3
.182	208	51.3	4,500	30	-4.1	4.2	-2.8	-.8
.249	212	72.7	3,500	28	-2.5	8.1	-7.1	-2.1
.320	214	95.6	2,500	28	-1.4	11.5	-4.1	-2.2
.366	215	112.1	1,500	33	6.7	20.5	-11.5	-1.7

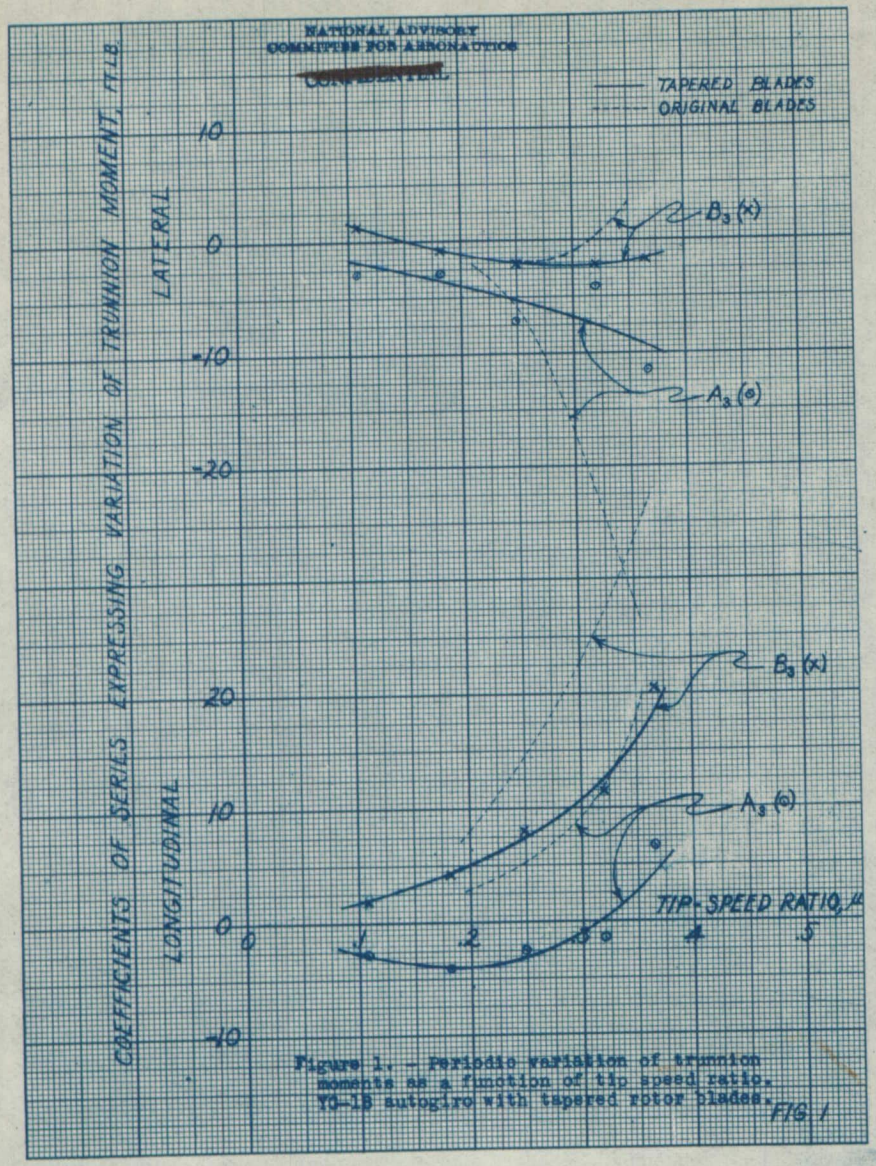

Figure 1. - Periodic variation of trunnion moments as a function of tip speed ratio. YO-1B autogiro with tapered rotor blades.

FIG 1

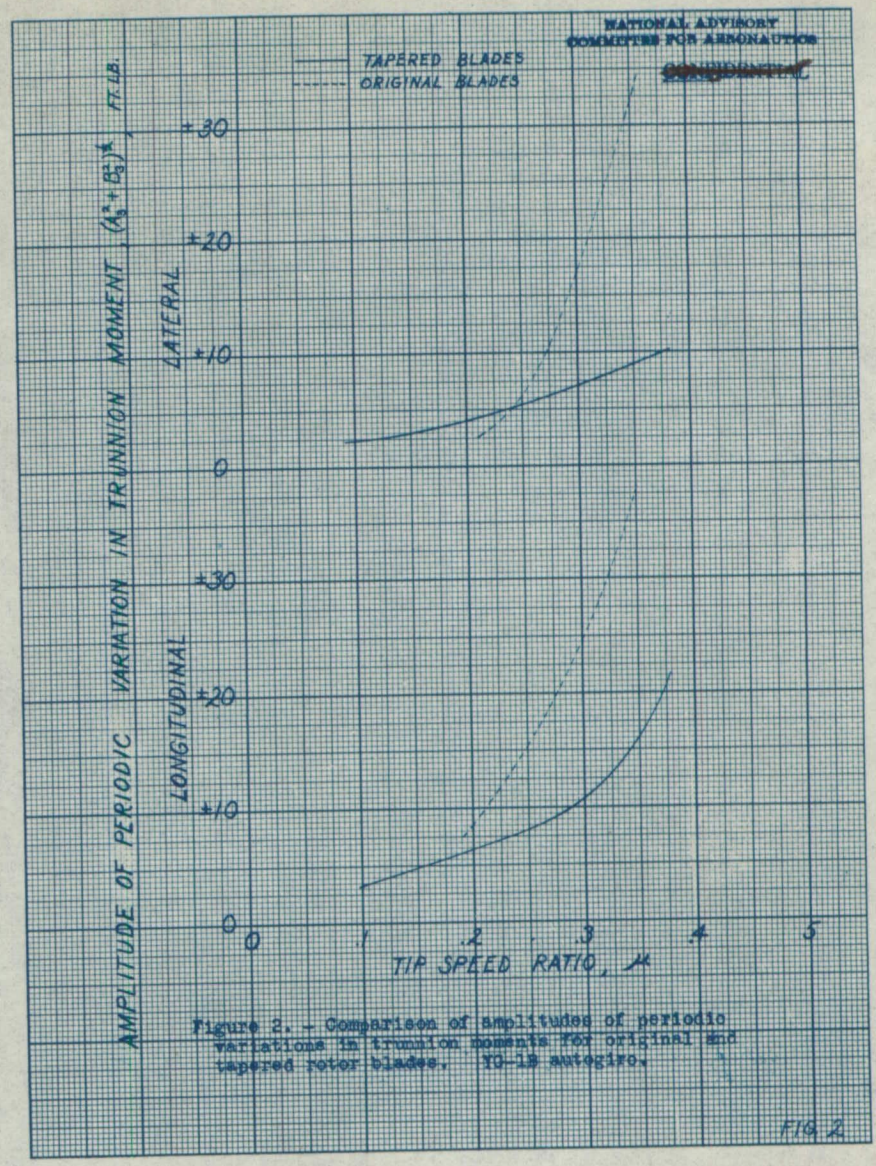

Figure 2. - Comparison of amplitudes of periodic variations in trunnion moments for original and tapered rotor blades. YO-1B autogiro.

FIG 2